



HOUSE OF LORDS

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The Select Committee on Science and Technology

Inquiry on

THE RESILIENCE OF ELECTRICITY INFRASTRUCTURE

Evidence Session No. 1

Heard in Public

Questions 1 – 16

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10.40 am

Witnesses: Dr Simon Harrison and Professor John Loughhead

USE OF THE TRANSCRIPT

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Members present

Earl of Selborne (Chairman)
 Lord Broers (co-opted)
 Lord Dixon-Smith
 Baroness Hilton of Eggardon
 Lord Hennessy of Nympsfield
 Baroness Manningham-Buller
 Lord O'Neill of Clackmannan
 Lord Peston
 Viscount Ridley
 Lord Rees of Ludlow
 Lord Wade of Chorlton
 Lord Willis of Knaresborough
 Lord Winston

Examination of Witnesses

Dr Simon Harrison, Chair of the Energy Policy Panel, Institution of Engineering and Technology, and **Professor John Loughhead**, Royal Academy of Engineering

Q1 The Chairman: Welcome to our two witnesses—our first witnesses for the formal evidence session on this inquiry. We are very grateful to have this contribution from the engineering community. I am going to ask Dr Harrison and Professor John Loughhead to introduce themselves in a moment and make any opening statement they would wish, but first I congratulate Professor John Loughhead on his appointment tomorrow, I think it is.

Professor Loughhead: It is indeed, Chairman, so thank you very much. They were keen that I should get this over with.

The Chairman: We have caught you before you are inhibited by the cares of office.

Professor Loughhead: That is right.

The Chairman: Excellent. I remind colleagues that they will have to declare interests when they first speak. Would you like to introduce yourselves and say anything by way of introduction?

Dr Harrison: Thank you, Lord Chairman. I am Simon Harrison and I am representing the Institution of Engineering and Technology. I chair its Energy Policy Panel and we have reached back into our 150,000 members to form views about these kinds of things so I hope this is the concerted view of the engineering community in this area.

I declare an interest. I have a day job with Mott MacDonald, the engineering management and development consultancy. For an opening statement on resilience, a lot of your questions for today are about capacity margin and that is very important especially in the short term, but resilience is about a lot more than capacity margin. The response we provided to your consultation request explored a wide range of issues around electricity system resilience. The first thing to think about is that, in the engineering sense, resilience is

a system property. It belongs to the whole end-to-end system from large power stations and even their fuels supplies, manufacturing supply chains, everything else through to what happens beyond the electricity meter in consumer premises. One has to think about resilience in the round and not in pieces, because if you think about it in pieces you will tend to end up missing important interactions.

The electricity system is a very complex system and it has worked very well, which means that we tend to take it for granted. Its resilience and engineering integrity are governed by a series of statutory appointed Code Panels and such like. It is about to transform and while generation capacity is a major concern for the short term, the much wider concern is what in Germany they call the *Energiewende*—the transformation of the system as we decarbonise it.

That is going to mean that the system becomes immensely more complicated. There are going to be immensely more cross-system and along-system interactions that need to be understood, managed and controlled. There will be many, many more automatic control systems engaged, ranging from systems for charging electric vehicles in people's houses through to systems that deal with the technical management of the electricity system itself. There are issues of cybersecurity from end-to-end on the system as information and data become much more important to it. A lot of smartness is coming in, with demands from consumers for great smartness in the way they interact with the system and a massive expansion of renewable energy, and potentially distributed and community energy.

If you engineer all that well you will end up with a more resilient system. If you end up just hanging all these things on to what we have at the moment you will end up with a very much less resilient system that could well fall apart under particular circumstances, not all of which we could predict at the moment. The important message here is all about end-to-end systems engineering. Nobody at the moment is responsible for that. The IET is very keen to establish a proper system engineering function within the UK electricity sector and, as you will see, we majored on that in our response and you may have some questions for us about that later. In the short term of course, you are interested in capacity margins and we are very pleased to try to help with that if we can.

The Chairman: Thank you very much. Professor Loughhead, would you like to say anything?

Professor Loughhead: Yes. Thank you very much, Chairman. My name is John Loughhead. I am currently executive director of the UK Energy Research Centre. I am here today representing the Royal Academy of Engineering, where I am chair of the engineering policy committee. I should also make clear that I have been a member of the IET's Energy Policy Panel and indeed its past chairman for several years.

In terms of this particular inquiry, the Academy very much supports the detailed statements made by the IET and there is not very much that we would want to add to what Simon has just said as an opening statement. However, there are probably two issues that I would like to emphasise. The first is that we currently have a system that was designed and engineered some 50 or 60 years ago as a predominantly electro-mechanical engineering system with an assumption that most of the users of electricity were what we would call in engineering terms "passive loads". That is they are dumb. They just consume. They are either switched on or switched off.

As Simon has highlighted, we are moving to a very different system in a context where much of the spare capacity that existed in the system 20 or 30 years ago has gradually been exploited and consumed. We now are operating on much smaller margins than we traditionally have and we are putting the new systems into both the generation and supply side but equally into the consumption side where we can no longer assume that some of the traditional tools such as voltage adjustment will necessarily result in control of load because of the intelligence and the reactive nature of many of the loads that are on there. Apart from that, I think Simon has very well summarised it.

Q2 The Chairman: Thank you very much. We will move into our questions, but before I ask the first question I should declare my interest as an honorary fellow of IET, a fellow of the Royal Society and chairman of the Foundation for Science and Technology.

In the evidence that you have given us, and indeed others, it is clear that in practice over the last 40 years or so the system has been highly reliable. The IET point out that the three-day week in the 1970s was the last time there was a serious issue. However, we seem to be in a situation now where the margins are narrower than they have been for a very long time. There are clearly some unexpected outages: we have just had a fire at Didcot, for example, and there are nuclear power stations and other power stations with planned closures. It is looking rather more precarious than perhaps it has for some time. Is this a concern over the next couple of years or so, certainly until the new balancing systems and the like come into existence? How have we got into a situation where we appear to have rather narrower margins than is comfortable?

Dr Harrison: You have highlighted the short-term concerns. Until the weekend we had about 2 gigawatts of plant on unplanned outage for well-publicised reasons and we now have another 750 megawatts or so. When you add that, you are talking about 5%-ish of peak demand. We do not really know when a lot of that will come back but it is a fair bet that we are unlikely to see most of it during much of the high-load periods during the winter. It has exacerbated a problem that was already there.

National Grid has been putting arrangements in place to procure what it calls “balancing services” in the short term from mothballed power stations, from industrial users who can deload and other such sources. Potentially that provides us with a few gigawatts of opportunity to help balance the system. There are opportunities around reducing system voltage but they are underexplored. We have not been in a situation where we have had to do that in a systematic way for many years. Frankly, we do not quite know what the extent of that opportunity is. The received wisdom is about 5% but, as John was saying, the nature of the load has changed. We have a lot more power electronic loads. National Grid will be the first to say that they are surprised sometimes with how load is now behaving. The implication of that is that, whereas you used to be able to reduce voltage and load would come down roughly in proportion, you now reduce voltage and you are not quite sure what is going to happen. There will, no doubt, be some discovery and there is certainly some opportunity around reduced voltage. As to whether the system will remain together and operating, yes, it will. There are, in extremis, means to manage load on the system. In other words, controlled disconnections of industry and such like can be done and will keep the thing on and lights available to ordinary consumers. We are much closer to the wind than I think we would probably like to be.

The Chairman: Professor Loughhead?

Professor Loughhead: In addition to that, the academy last year published a report on capacity margins and highlighted the fact that the result of the exploitation of unconventional gas particularly in the United States had caused a significant release of United States coal on to the north-west European market. That depressed prices. What it meant was that gas-fired power plant for a long period became uneconomic to operate and so you saw a dramatic increase in the amount of coal-fired power generation in this country.

Prices of gas have been supported by the closure of nuclear plants in Japan and the increasing amount of LNG on the world market, which has tended to exert an upward pressure on gas prices that has reinforced that. Then the incentivisation of renewables deployment in the UK has made, for many commercial investors, the outlook for gas-fired plants less certain. Therefore they have tended to shy away from investment in the UK environment because they are concerned about the risk of stranded assets. This is with a number of companies who also are countering the effect of the German Government's decision to close nuclear plants early in Germany, which has hit the balance sheets of many of them and made them much less resilient. What we are seeing is a combination of world effects, the normal ups and downs of system operation, and the impact of some of the European policies and UK government policies, which have conspired together simply to take away what would have been the normal reaction of the operators of, "Let us invest".

The Chairman: As an engineering community, you must be a little bit disappointed at the inability of those who plan these things to have anticipated these issues. Clearly the capacity market measures that have been taken are going to be expensive and that may be money that, quite frankly, could have been better spent in investment.

Professor Loughhead: We are engineers so we face disappointment every day, Chairman, but one of the issues that we are disappointed about is the fact that it has been obvious for some years that we have needed to take a more active role in looking at what the overall engineering conception of the system is going to be, but there has not been anybody so far who has been in the position to take that responsibility within the UK. What we have been doing is exploiting a system that we have. We can see the looming need to start to design it differently but at present it is not clear who is going to take up that responsibility.

Q3 Lord Wade of Chorlton: Thank you very much for that because I think you have created a very interesting point. I agree with you about this, if you like, Mr Energy, who can see all these issues, because we have never had anybody who can see the whole picture for a long time, if ever. The issue you raise is about the fact that we are no longer in the UK market; we are in a world market. Somehow or other this is not dawning on people to the extent that you would have thought it would. Even in my understanding of the agricultural industry, it is amazing now how it is world prices that decide the price of milk here and not what is happening here—an unheard-of situation, really. Are we not understanding, when we come to energy, that if we do not appreciate what other countries do will affect us, what is the point of us going to extreme cost to achieve an aim when somebody else takes exactly the opposite view and creates energy on a much more cheaply or does not take the same interest in controls or regulations or laws that we might? What they do will affect our market. How do you respond to that?

Professor Loughhead: The point that you make that we are operating now in a much more interconnected world is very good. It applies for the price of energy. It applies for the supply of the equipment. The last time we had a major expansion in this country, predominantly it was indigenously manufactured and designed. If we now expand the electricity system probably 80% or more of the equipment will have to be sourced from outside the UK because we no longer have such industries in the UK. The other factor that is worth reporting is that many of these organisations are making commercial investment decisions and there are a number of markets in which they can invest. It is not a matter of saying, “What is the best option in the UK context?” It is the question of saying, “Shall I put my money in the UK or shall I invest in Brazil and Venezuela or should I be putting it somewhere else?”

Lord Broers: I have a detailed question for Dr Harrison.

The Chairman: Declare your interests.

Q4 Lord Broers: Yes, and declare my interest as a fellow of the Royal Academy of Engineering, the Royal Society and the IET. You mentioned using voltage drops. Somewhere in your report, I think, I was surprised that you said that a lot of local generation will disconnect if that happens. How serious is that problem?

Dr Harrison: Local generation will not disconnect ordinarily if we manage the system voltage down a bit. Where it would disconnect is if there was a fault on the system or an excursion of frequency, such as might occur if, say, a large power station tripped out. That causes a short-term transient in the system frequency. Among the controls in small generation are things called rate of change of frequency relays, which are set to disconnect during fast frequency excursions. There has already been one round of resetting all those relays to different settings to make them less sensitive to make that happen less often. We are now in a process of having to go round and do all that again, make them less sensitive still, because clearly you want to be in a situation where you can use your local generation to help you recover from a frequency excursion. It is a very technical but interesting example of the need for systems engineering. The ROCOF relays were there for a particular purpose but we now have to look at them again.

Lord Broers: Will they be corrected by the crisis, the nominal low point that is coming up?

Dr Harrison: At the moment there is a programme of resetting of those relays ongoing. I am not personally aware—I do not know if you know, John—of what the time scale for that is.

Professor Loughhead: No, but it will be long. It will be a long time scale.

Dr Harrison: Yes.

Q5 Lord Dixon-Smith: I have no interests to declare. Are we not in some danger at the present time of allowing what I would call short-term market effects to drive what is actually happening? The depression of America’s coal price, which was keeping our coal-fired power stations going, is not going to end in my view, because the increasing prospects of shale gas being developed globally is going to keep the coal market permanently depressed. Of course then we have an immediate conflict with the long-term global climate ambitions if that is the way we allow our policy to be run. How do we prevent these short-term aberrations, which is really what it is, from taking control of events which we need to keep under control?

Professor Loughhead: Let me make a response to that. You cannot insulate yourself from short-term aberrations because, sadly, we still cannot see the future with any certainty. That is one of the reasons why we have advocated the need to look very carefully at what the underpinning engineering concepts of the future system are going to be so that we can be more tolerant of those changes but have a more responsive system within which we can adapt to that. If I may just quickly return to the previous point, one of the reasons why there is disconnection once the system goes outside certain limits is simply that the system architecture assumes that everything below transmission level is a distribution of electricity. One of the big dangers you have is if you do not stop everything working when the system has a fault is that you could be generating down at the end of a line where all the systems and processes tell you it ought to be dead. It is a hazard for the people who have to work on it and the systems cannot currently cope with that. We are stretching, with the embedded generation, the capability of the system beyond where it was. To return to your main point, one of the things we have to do in the future is be clearer about how we will cope with the inevitable uncertainties. We cannot control what is going to happen.

Dr Harrison: Perhaps I may add to that. If one looks back through energy policy and on roughly a 10-year cycle, the decisions, as seen looking backwards 10 years, are always wrong. There are external circumstances that change that we have to be able to respond to. It is unwise to be too prescriptive and fixed about how you look at the future but we do need perhaps something that is more considered than we have at the moment.

Q6 Lord Peston: I am going to ask you about balancing, which I confess I do not understand, so I want a layman's guide in a minute, but could I just ask you a question of context? Today it is bad weather and a lot of flights have been cancelled at Heathrow and a lot of people have been inconvenienced but there is no great song and dance about it. It just happens because an external shock has hit the system. Can you tell me why power generation is any different? Supposing there was an outage tonight so a lot of people could not watch Chelsea play European football. Would it matter? Are we not making too much of a song and dance about this whole subject? I speak as someone who was the first person ever to teach the engineers at Imperial some economics and that was 50 years ago.

Professor Loughhead: That is great. I might have listened to you. The issue about whether it matters is critical. The academy is currently preparing an extension to its report of last year looking at impacts of potential shortfall in supply. One thing that comes from that is that first of all it is very difficult to say how important it is depending on who you are. For some people it is critically important. This is embodied in the UK in something called "Value of lost load or willingness to pay". When you look at the evidence on that, it ranges from figures of about 20p a kilowatt hour up to £50 a kilowatt hour depending on who you are. The answer is that we do not know.

One of the reasons for that is that we have very little experience on which to base the concept of reaction. From what has been done in various parts of the world, there are two instances. People are very tolerant of what are seen as unavoidable external impacts. If a fire hits a power station or something dramatic happens, then they behave as "citizens"—that is the phrase. If, however, that persists for much time or alternatively it is seen that there is no response to it, people then move into being "consumers" and their response is, "Why has somebody not done something about it?"

Finally, to add to that, the last experience we had of sustained shortages was 40 years ago. Since that time we have become very much more dependent upon reliable electricity supplies. If you look simply at the City of London, most of the buildings would be utterly unusable. A two-day outage would start to become catastrophic and that is without talking about computers and all the rest of it. We are treading into very much unknown territory. We do not quite know what might happen.

Lord Peston: I literally do not understand what balancing does and what it is meant to do, so can you tell me what I need to know?

Dr Harrison: Okay, in concept it is quite simple. You cannot store electricity; you can only store it by converting into something else and then retrieving it. Because you cannot store it, you have to make it exactly as fast as you use it. We do not have Tesco warehouses for electricity. The result of that is you have to manage your supply to meet your demand at every second of the day, and National Grid is responsible for doing that in GB.

Within the market environment, we have generators and suppliers contract with each other to provide electricity to meet demand, but you can end up with an imbalance that you need to address in some way or another. You can address it either by reducing demand or by increasing supply, or you could address it if you have arranged to convert some electricity into another form to store it by recovering from your store. In the UK we have a few stores. They are large pumped storage hydroelectric stations that have been there for many decades, so you can store within those and recover to a degree. That is done on a commercial basis. Balancing is simply no more than the art of instantaneously matching supply and demand.

Lord Peston: That means, does it not, that the capacity has to be larger than the mean use. In stochastic terms it is the variance that matters and therefore balancing really has to give you the capacity that meets something at one great end of the spectrum.

Dr Harrison: Yes, you need more capacity by some considerable margin installed on the system than the maximum demand that you are likely to experience to allow for planned maintenance, for breakdowns and, in the more complex world we are now in, things like the wind not blowing when you might like it to. There is an elaborate way of calculating how much capacity you think you should need to keep the amount, the probability of lost loads, to an acceptable level. It can never be zero.

Lord Peston: What I am also supposed to ask you is, therefore: what can go wrong or what is likely to go wrong on present forecasts?

Dr Harrison: I guess where we are at the moment is the market has not brought forth enough new capacity that is reliably available at times of peak demand to offset the closure of old capacity, and the reason that old capacity has closed is not because of market issues but because of regulatory issues, because of emissions reductions and so on.

Professor Loughhead: Could I just quickly add to that? There is also the fact that the system is changing. As well as the elements that Simon has just mentioned, there are short-term lumps and bumps on the system due to sudden attachments or disconnections of load that you need to ride through and, if you do not—what we were talking about earlier—the rate of change of frequency causes protection to come in and the system to switch off. One of the issues that we have is that we were helped by the very large inertia of conventional coal-fired power plants, which would enable the ride-through of those lumps and bumps by using

the enormous kinetic energy stored in the system. Newer systems do not have that, so you need to reproduce it in some way and we do not have that to reproduce. The second element is that we can control some of this by using tolerances on the voltage that is supplied or on the frequency of electricity that is supplied. There are legal limits that they have to stay within but we can try to use those. But as we mentioned, the impact of those changes is being diminished by the intelligence of the devices sucking the energy in. The final point it is worth thinking about. We focus on generating capacity. We have to move it around the country. There are probably half a dozen pinch points on the national transmission system where a fault could seriously degrade the capability of the supply mechanism. All these things can conspire together. As you reduce the margins, the chances that you might go outside the acceptable envelope increase, and the longer you try to operate at those margins, the cumulative risk of something going wrong tends to increase.

Q7 Lord Rees of Ludlow: I have a comment and a question. The comment was in the evidence we had from Professors Grubb and Newbery, who thought there might be a risk of paying too high an insurance premium for this. Maybe you would like to comment later. But I would like to ask the question: when these rather precise figures are quoted, like the one in 31 years and one in 73 years, what are the main risks? Is it systems breakdown or is it extreme weather? Also, I worry that the circumstances are changing decade by decade, so we do not know what the risks will be 20 years from now. I wonder if you would comment on those. I should declare an interest as a member of the Royal Society.

Professor Loughhead: Can I just clarify the figures? You said one in 73. You are quoting those from where?

Lord Rees of Ludlow: Yes, Ofgem figures.

Professor Loughhead: Ofgem figures?

Lord Rees of Ludlow: Yes.

Professor Loughhead: All right. Well, they must be right then. Do you want to say anything on that?

Dr Harrison: What are the main risks?

Lord Rees of Ludlow: Yes.

Dr Harrison: I think, historically, the main reasons why people have gone off supply have been nothing much at all to do with generating capacity. They have been mostly to do with distribution system performance and a little bit to do with transmission system performance, and a tiny bit to do with generating capacity. So we need to just keep that in our minds, I think, when looking at this whole resilience issue. My opening statement and our submission were directed around that. Going further into the future, distribution system resilience and its interaction with supply we think will become the main game in town around system resilience. Therefore the importance of looking at the whole thing end to end just gets bigger and bigger. In the shorter term, we have this concern about supply, available capacity and the ability to manage demands to keep the system balanced.

Lord Rees of Ludlow: That is in case of extreme bad weather.

Dr Harrison: That is in case of mixes that are changing. It could be very cold weather that produces high demand at the same time as producing low wind conditions, for example.

That could be a pinch condition. Other pinch conditions could be around unexpected outages of, say, nuclear plants. If you combined all that with, say, a well planned terrorist attack, you could be in quite a mess. So it is those kinds of issues, I guess, in the shorter term.

The Chairman: Your reference to the distribution system reminds me that perhaps I have another interest to declare, and that is that I spent Christmas without any electricity—a failure of the distribution system—and it gave me a rather jaundiced view about the communications of the company, which was pretty inefficient.

Q8 Lord Dixon-Smith: We are now fairly well informed on the problems of the supply side, but increasingly we are going to have to go into the question of managing the demand side. Could you just expand on how you see that going into the future?

Dr Harrison: Setting aside the problems of this winter, I think the question is aimed a little bit into the longer term, is it not?

Lord Dixon-Smith: Yes.

Dr Harrison: There are all sorts of opportunities around this, because there are large amounts of industrial and commercial demand where you have intelligent actors who are able to make rational, commercial decisions about when they take electricity or when they do not take electricity. The classic example is supermarket refrigeration. There is no reason why, at a time of peak, you cannot contract to turn some of that off and receive a commercial benefit for so doing. This is happening now and will happen to a greater degree in the future. The transformation, I guess, is when you start to extend that into people's houses and you start to envisage contracting for blocks of demand within residential premises. There are some experiments going on with that at the moment. The smart metering programme will help make that a little bit easier.

But there is a whole end-to-end piece around this, because if you do start doing interesting things with consumer demand, you need to start worrying about the impact on distribution networks, for example, voltage control and suchlike. It is all linked in also with things like solar PV panels on people's roofs and what that does. If we move to a world of electric vehicles or heat pumps, they have massive implications for demand levels. So the average demand of a house at the moment is about 1.5 kilowatts, while an electric vehicle charging load is about 7.5 kilowatts. So you have really major implications if you move to that, including for distribution systems. You start to get to a place where you need to understand both the impact on supply-demand balance of managing demand and the impact on the network. That is a major concern that we have, because there is nobody looking at that. You are either a generator selling electricity and you are very interested in managing when your customers take it, perhaps, or you are a network company trying to manage your network, but there is no real interaction there. That is an interesting issue. The other one that we foresee that potentially could come up and just overtake a lot of this is big consumer brands like Apple and Google, who are investing heavily in consumer energy products at the moment, coming in and capturing people's imagination and taking control of their domestic energy economy in ways that we can hardly imagine that will have deep, profound and rapid implications for the electricity system. The chances are that that would happen in a completely disconnected way from what is happening in terms of how network companies act and invest.

Baroness Manningham-Buller: Can you explain the Google-Apple thing? I do not understand.

Dr Harrison: For example, Google has spent a lot of money acquiring a business called Nest, which makes intelligent thermostats. Now that might not sound very Google. A thermostat does not seem to be a particularly sophisticated device. But they are seeing that as part of, I guess, a service offering where they can provide an intelligent, very controllable, very user-friendly home energy control service. In a way, I suppose, the smart metering programme is an early step along that particular direction. But you imagine the transformative power of Google, in terms of disrupting a business model, and providing an offering to you as a customer that you find highly attractive, that reduces your bills and takes a significant element of control of the energy in your home. Now, the thing that is interesting about that is not just that it can happen but the way consumers behave when that kind of disruptive change happens.

We have seen it with mobile phones or with deployment of solar PV panels. It can happen really fast. The electricity industry tends to work in timescales of many years to implement changes. The consumer electronics industry works in two- or three-year cycles. So, if we suddenly got to that place where, in 10 years' time we were sitting around this table and you were all driving Google cars and you were all controlling your home with an Apple home control app, then the implications of that for electricity system investment, which tends to be rather slower moving, could be profound indeed.

Baroness Manningham-Buller: I should declare an interest. I am chair of Imperial College.

Q9 Viscount Ridley: I declare an interest in coal mining, one wind turbine and shares in Rio Tinto. Just to pursue a bit more what happens on the high peak demand periods, there is a short-term operating reserve, which the system has been building up to switch on for minutes, hours—I am not quite sure—and a lot of that is dependent on diesel generators, am I right? How much diesel, as it were, are we going to burn to keep the lights on in the next winter?

Professor Loughhead: The answer is not a lot, in the sense that these are to shave off short-term peaks, to stop the point where the system would need to start switching off for protective reasons. So the total amount of operation is probably at most a few 10s of hours per year.

Viscount Ridley: Okay. But is it sitting there waiting if we need it? Is it big enough?

Professor Loughhead: It is sitting there doing it. I honestly do not know. Everybody hopes it is, but we will find out.

Q10 Lord O'Neill of Clackmannan: Can I first declare an interest? I advise the Electrical Contractors' Association and I chair stakeholder advisory panels for both Scottish Power and National Grid. Could we return to the capacity market? You either forgot or sidestepped the question that Professor Rees raised on the Newbery and Grubb criticism, and I wondered if you could perhaps say whether or not you accept their view, or what you think of their view, that 53.5 gigawatts is in fact excessive, that we have targets of investment that are higher than we require? What is your view on that criticism?

Dr Harrison: It is certainly a risk. The way in which that 53.5 gigawatts has been set has been a piece of analysis done by DECC and by National Grid that essentially makes a whole series

of technical assumptions about all manner of aspects of plant performance—availability data for thermal and nuclear power stations, ramp rates and the whole gamut of technical parameters. All those are subjective. Imports off interconnectors is another quite contentious one. You have to form a view as to where you think each of those should sit. Rather than necessarily challenge the 53.5 from the top, you have to start with all the inputs and look at them. The IET feels that some of those choices were made quite conservatively. However, we can understand caution because the costs to society of getting that 53.5 gigawatts too low by, say, 3.5 gigawatts are much higher than the costs of getting it too high by 3.5 gigawatts. So there is a drive towards caution in approaching this, but certainly the IET is on record as having made comment that we feel that some of those numbers were set perhaps a little too cautiously, but we can understand the thinking behind doing that.

Lord O'Neill of Clackmannan: It is a fact that the old system, the publicly owned one, lent itself to gold-plating, and I would imagine the received wisdom in the industry still has a residual element of that within it, so that would perhaps give some weight to this, if not criticism, certainly questioning, if I can put it that way.

Professor Loughhead: I think you are probably right, because we have a whole generation of people in the industry who have been trained to assure supply. It is the old phrase of keeping the lights on and, of course, we can engineer a system to be as secure or as unsecure as you want. It is always a question of how much do you want to pay for it. I think that is one of the reasons, and I am sorry if I am anticipating your next line, why the engineering community has been advocating a system analysis of what it is that we are going to do, with a view of saying how can we most efficiently engineer the system, with all these different characteristics that policies demand we have.

Lord O'Neill of Clackmannan: Can I just ask you then—looking for a one word answer—whether you think that the present process of establishing these figures has been insufficiently rigorous?

Professor Loughhead: I am sorry, but it is more than one word. I think that the process has been imposing upon the system that we have inherited the moves that we believe we can make to get the performance that we want. Perhaps that is not the way we should be doing it, going forward. We should be taking a more fundamental look at how we are going to design and structure it.

Q11 Lord O'Neill of Clackmannan: Perhaps we could just move on to one other issue. We have already spoken about the availability of gas in North America and its depressing effect on coal prices, therefore making it more attractive for our coal stations to be fired and operating. How long do you think this can carry on? Will the capacity market assist this process of making coal fashionable once again? There is, at the back of all this, both the EU and our own carbon emissions reduction targets. What do you think the consequences are for both the life of coal and, as a consequence of that, the carbon emissions target problem?

Dr Harrison: That is an interesting point. Most of what is going to determine how many hours the UK's coal fleet operates is nothing to do with carbon. It is limits that were set by the EU to do with sulphur emissions and nitrous oxide emissions. So there is the Large Combustion Plant Directive 2, which is around sulphur emissions, and another one called the Industrial Emissions Directive, which governs nitrous oxide emissions. Now, the impact of those is that most, if not all—probably not quite all—the coal fleet in the UK has a clock

ticking in terms of the number of allowed operating hours that it has remaining. Whether it uses those operating hours quickly, by running hard to take advantage of the coal price, or whether it deems it more commercially advantageous to bid into the capacity market and use those hours over a long period and receive capacity payments is a commercial decision for the operators of those plants. The impact of that on carbon emissions will be neutral, give or take, because the number of operating hours will be the same, whether they are spread over a couple of years or another 10. If we are to see a longer-term future for coal-fired generation in the UK, we are then looking at carbon capture and storage possibilities, either as retrofits to existing plants or as new builds. Of course, the CCS competition that the Government is organising is live, and there are two parties that are looking hard at their feed studies at the moment. We may see, with supports, positive developments coming from that that would allow continuation of coal-fired generation with much reduced carbon emissions.

Lord O'Neill of Clackmannan: As engineers, what do you think the chances are of securing, within our lifetimes, CCS?

Professor Loughhead: Can I answer that? As engineers, no problem. The question is: will the market conditions make it possible? I was in Canada just over a week ago, talking to the people running the CCS plant there. Their big problem is, they say, that it just does not stack up economically, because it costs twice as much to build, it costs 30% more to run and, at the moment, there is no mechanism to get the money back. Doing it is not the problem.

The Chairman: Thank you. That brings us on to decarbonisation, and Lord Ridley has a question.

Q12 Viscount Ridley: Yes. You mentioned a little earlier that the coldest periods are often the ones with the least wind, and in December 2010 we had a particularly still and a particularly cold period. We nearly ran out of gas at the point, as I understand. If that had happened now when, first, we are more dependent on wind and, second, we have a series of outages and our capacity is lower still, we might be in trouble. I am not asking you to judge how likely that is. The point is that there is no question, surely, but that renewables reduce the resilience of the system.

Dr Harrison: That depends. If you are looking at resilience against fuel supply shocks, against gas price and suchlike, renewables increase the resilience of the system.

Viscount Ridley: But what about gas prices falling? They reduce your ability to cash in on that.

Dr Harrison: They reduce your ability to cash in on that. Resilience is a very complicated and multi-dimensional issue. You can view it through all sorts of lenses and, of course, people who favour particular technologies choose their lens. We try to be as balanced about this as we can, in the engineering profession. Renewables certainly have a contribution to make in reducing the risk of fuel price volatility and the risk of fuel supply. However, they have significant consequences for other aspects of resilience to do with capacity, and also to do with network performance. So we are moving to a world, as we decarbonise, where resilience could be quite severely compromised if everything is not engineered properly. As engineers, we can fix that, but we need the ability to look across the whole system to allow us to do that.

Viscount Ridley: You can fix it, but at a cost, presumably. In other words, you talked about it ensuring against volatility of fuel prices and so on, but only by raising the cost of electricity.

Dr Harrison: We are getting into a space that goes somewhat beyond engineering.

Viscount Ridley: I am sorry. That is fine.

Dr Harrison: If we engineer it properly, we can fix it at a much, much lower cost than if we simply react and fix the problems one by one as they emerge. If we were to choose not to deploy renewables and to do something else—for example, to fill the UK with nuclear power stations—it is potentially a viable solution, but you end up with a whole lot of other resilience issues. They revolve around skills, around the supply chain, around dealing with the spent fuel and decommissioning issues in the long term, and so on, on a much greater scale than we have now. So these debates are very complex and multi-dimensional, and beyond engineering. As engineers, we can build you whatever system you would like, but it is a matter of what the public want.

Q13 Viscount Ridley: Can I ask you about storage, because there is a lot of hope that efficient storage, in batteries or some other form, can solve this problem of renewables being dependent on what happens to the weather? On the other hand, I have seen some studies—there was a study that came out of Germany recently—that even if you take pumped hydro storage, which is the most efficient form of storage, and add that on to wind—you firm wind with that—the effect is basically to lower the energy return on energy invested in wind to the point where it is uneconomic. Have you seen that, and does that worry you? In other words, however good batteries get, they cannot make wind economic if you are storing it.

Professor Loughhead: Could I make a response to that? I think, if I may say so, you need to think of storage much more broadly than that. It is not just about storing electrons. There are all sorts of ways in which you can store energy. We inferred it before, talking about using the thermal inertia of refrigerated or deep freeze stores as an energy swing methodology. You can do the same thing with heating. There are many different ways in which you can store energy. Every system that is going to be engineered is going to need energy storage in it in some form or another, whether it is a pile of coal at the entrance of a power station, whether it is a gas store somewhere in the North Sea, whether it is a thermal store or whether it is a mass of batteries. The question is, rather than picking the silver bullet of electricity storage, to say what your system is going to look like overall and how you will you create the necessary storage within the energy system in totality, because the electricity system is not wholly separated from the heat system and the transport system.

Dr Harrison: If I can give one example of that, there are opportunities that have been exploited in some countries for inter-seasonal heat storage in aquifers under buildings in cities. So, the excess heat in a building in the summer is stored underneath the building and recovered during the winter.

Viscount Ridley: I suppose I am specifically saying: how do you store wind energy?

Dr Harrison: There are all sorts of possible mechanisms, which mostly have not been exploited. One obvious use is, for example, if there is far too much wind energy at a particular time, you could store it very simply in everybody's domestic water tank via an immersion heater.

Q14 Lord Broers: This one is rather specifically for you, Dr Harrison. The IET has called for a new systems architect. Can you explain why this systems architect is needed, and what form

it should take? I might add my own slant to that, in that DECC, for a long time, has had a calculator that to me as an engineer was quite remarkable because it completely ignored cost. Do you think that this architect will be able to look at the whole system, including cost? What is your concept for this?

Dr Harrison: We are thinking about the functionality of this because we think the need to look across a whole system that is becoming very complex and changing very fast is missing at the moment, and needs to be filled. As to the precise form of where you put it in government, and who it reports to, and all the rest, lots of people want to draw us into that conversation but we are trying to avoid it because we think it is not an engineering problem. The engineering is about why we need it and what it should do. We think that, because there are massive changes coming in the way our electricity system, and indeed, our whole energy system is going to be in coming decades, we need to do some proper systems engineering to understand that. In fact, it is interesting. We have done some work funded by Innovate UK on how this is looked at in other sectors. If you go and look at other complex engineering sectors and try to have a conversation about why you need systems engineering, they look at you askance and say this is a bizarre conversation. It is an absolute basic thing that you need to look at the engineering of a whole system.

What we would like a system architect to develop an end-to-end understanding of is, for example, all the interactions of control systems that are going to happen on this very complex, data-heavy system that the electricity system is becoming. Just by way of examples, and I can hand this out if it is of any interest, we have at the moment about 10,000 automatic controls on our distribution systems. They are things like transformer tap changers. The calculations we have done indicate that, as the system smartens, that 10,000 changes to 900,000. So you then have 900,000 interacting systems to start to worry about, which nobody is taking care of right now. We, at the moment, control the frequency with 10 to 15 generators in frequency control mode. We potentially could see that increasing to somewhere north of half a million, when you start to include all the autonomous generators locally connected at small scale.

If we move to very intensive home energy management, which I think is highly likely, we move from almost nothing at the moment to perhaps 15 million [control systems], if half the smart meters that go in link to energy management devices. So you are ending up with a data-heavy system with many different controls going on within it, which needs to be thought about end to end, because if you do not, you will end up with control systems fighting each other. For example, if you decided, because the wind was low, that you wanted to turn off all the fridges in Kent one summer's evening, that might be a rational thing to do. However, if at that point the sun suddenly came out and all the solar PV in Kent started generating, you end up with serious voltage rise problems around the network in Kent that need a proper control response. Unless all that is thought through, you have a risk of voltages going outside limits, equipment damage, and so on. You can come up with many examples that explore and clarify why you need this end-to-end view. What we do not want is another CEGB. This is not a bunch of engineers asking for another CEGB. The CEGB was not a particularly cost-efficient way of delivering. It is about a systems integration activity at the engineering level that runs in parallel to economic regulation, the role of markets and so on. It is not working against any of that, but it is providing the systems rigour that is missing at the moment.

Q15 Lord Broers: What does this proposal mean for existing actors with responsibility for electricity system resilience, particularly the Government, the National Grid and Ofgem?

Dr Harrison: National Grid, I think one can argue, takes the lead within the industry at the moment and its job is to balance the system and to provide the transmission infrastructure for bulk transfer of power. What it does not do or understand—and would be the first to claim, I think—is what happens on the distribution system, what happens to the customer side of the meter, which is becoming increasingly important, or how consumers behave, which is a significant issue going forward as customers become more engaged with their supplies, as we expect to happen. So, National Grid has a view of a system, but not a view of the complete system. This is going to be quite tricky, because it is a dominant and very knowledgeable player, but it does not have a complete view. A system architect needs to be positioned to have that complete view but not to interfere unnecessarily in the proper business of a company like National Grid, which does have a large competence, and nobody wants there to be unnecessary technical arguments between what National Grid should and should not do within its sphere of activity. But National Grid's role within a total system is very much part of what a system architect should get involved in.

If you look at Governments, DECC, of course, is the owner of policy in government and the system architect is not envisaged to be any kind of policymaking body. The system architect is an engineering systems integrator. The system architect we would expect to be a trusted adviser to DECC by providing the engineering knowledge that allows DECC to think about and understand the engineering implications end to end of policy decisions and, hopefully, then to make better policy decisions. It is not making policy but what it—

Lord Broers: Is it a person or a committee or what is it?

Dr Harrison: That is one of the questions we think is unanswered. It could, at one level, be a committee. It could, at another level, be a staffed body carrying significant expertise. That is something that needs further development by the industry and with Government to understand what this thing is and what its rules of engagement need to be. At the moment what we are trying to do is to get the whole subject into the productive debate that is about confirming that it is needed and then thinking about what its form should be and what its remit should be.

Lord Broers: You are defining a need, rather than an actual committee or person. This is the very beginning of solving this issue.

Dr Harrison: Yes, it is. We have produced a number of reports—which we would be very pleased to share with the Committee, should you so wish—which set out the thinking as it has emerged. We have explored what is done in other sectors. We think now we have a case that is reasonably well set out as to why it is needed. From our point of view our next steps are to look at the engineering of that and what the scope needs to be. It is quite a different question from what most people seem to want to ask us, which is who it is or where it should sit. We are trying to not answer that question because we think that is leading the witness. We would much rather say, in engineering terms, what it should do and then leave it, essentially, to Government to work out how it should be—

Lord Broers: This is an example of engineers being politically naive, whereas politicians are financially naive.

Dr Harrison: We may be politically naive. In this company, I have to say, we are, almost by definition. But we are trying to engage at a level that builds a consensus of understanding and acceptance of need, rather than polarises a debate where you say it should be part of Ofgem and you say it should be part of DECC and you say National Grid should do it and you say it should be a new body and you say it is not needed at all. We are trying to get away from that at this stage to focus on need and develop scope and build an understanding that this very, very complex system that we are moving towards needs proper systems engineering.

The Chairman: We are running out of time on this session but I want to take Lord Willis and then Lord Wade.

Q16 Lord Willis of Knaresborough: Could I just follow up? I was disappointed that you did not give us your solution to what in fact this architect should be because, as a Committee, it would help us if in fact we had a steer in order for us to debate that and then have a recommendation. Perhaps you could think about that and say, in an ideal world, if you were sat on this Committee, what your solution would be, because that would be helpful. But the question I wanted to ask you is this. Most systems that we see, particularly around Europe rather than the States, were all monopoly systems that were basically set up and engineered by organs of government in the past, so everybody must in fact be dealing with the same problem. Is there anywhere that you could point to that in fact has a system analysis and has converted that into a policy proposal in order to secure both their supply and their resilience?

Dr Harrison: Answer: not yet, but lots of people thinking about it. For countries experiencing similar issues to the UK—for example, Australia and Germany—it is very much in debate. The UK is relatively unusual, as we have liberalised rather more than everywhere else, which has had large numbers of benefits but has also produced greater fragmentation in the industry than elsewhere. That works against end-to-end systems engineering. We are very open in terms of consumer markets, which is why we are likely to be attractive as a test bed for new ways of managing energy in the home and bringing energy to people. We are ahead of the curve. The country that is experiencing the issues around renewables more than anyone else is Ireland and so there are, potentially, some interesting lessons to learn from Ireland. But Ireland is less well advanced in terms of some of the issues around consumer interactions and so on.

The Chairman: I must bring this to a close. Lord Wade, finally, a short question.

Lord Wade of Chorlton: Very quickly, Chairman. But also I will just say that my interests are that I am a director of a fund management company where we invest into a whole range of different companies. The question I was going to put to you is that I have sat on a number of Committees—two Committees other than this one—looking at energy issues and we always ended up asking the question: if the lights go out, who gets fired? When you think about it, you always get a very confusing answer because there are so many people involved that there is nobody whom you shoot if the light goes out. Are you adding to that pile of people who can always say, “It was not my fault that the lights went out, it is his fault”? I come to the conclusion, when I hear you talk, that there is only one way of running our energy policy and that is with a bloody big computer that is given the responsibility to take in all this vast amount of information and tell us the day before, “The lights are going to go out tomorrow”. Am I right?

The Chairman: A quick reply.

Professor Loughhead: A quick reply to that is that operationally there is no one responsible to do that. The point that Simon was expounding was that we need to accept that as we move towards the utterly different components that stretch our current system beyond its capability, we need to approach its design in the right way. I do not think we are adding to the operational confusion; that is another issue.

The Chairman: Dr Harrison, you said that there was a document you would like to circulate to the Committee. If you give that to the clerk afterwards, he can send it around by e-mail. I get the feeling on this systems architect that this is very much at the moment a matter for discussion, so if you develop your thoughts further, of course, we would be very interested to hear. I have no doubt we will refer back in future evidence sessions to your interesting ideas in that respect. For that and for the other evidence you have given us today we are most grateful. It has been very helpful. Thank you very much.